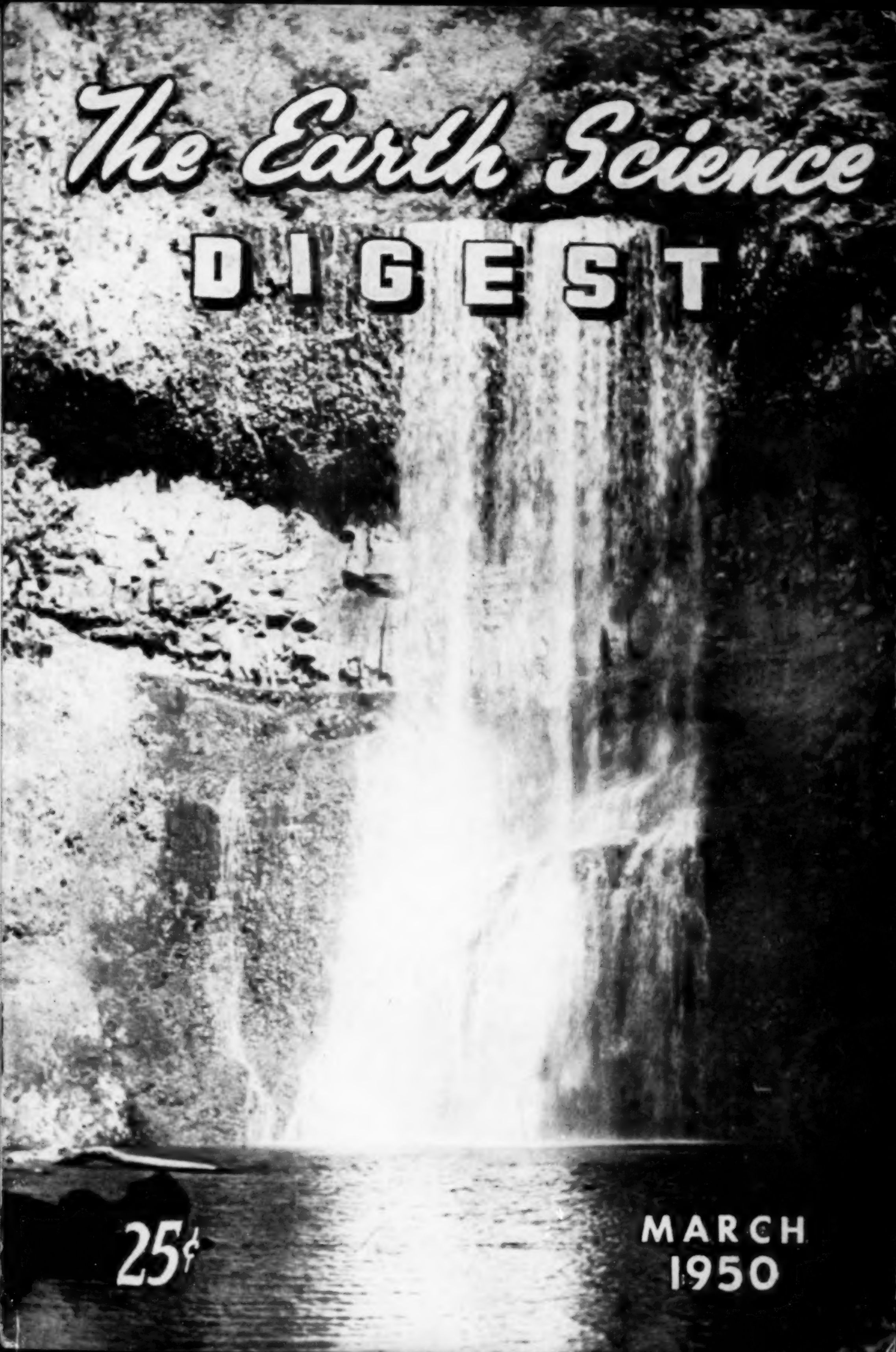
# The Earth Science DIGEST



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MARCH 1950

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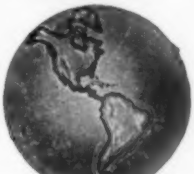

*A magazine devoted to the geological sciences.*



THE EARTH SCIENCE DIGEST is open to articles of geologic interest. Manuscripts, photographs and sketches will be returned if accompanied by ample first-class postage.

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## Meetings and Conventions

Seismological Society of America, Annual Meeting; Cordilleran Section of the Geological Society of America, Annual Meeting. April 7-8, 1950. University of Washington, Seattle, Washington.

Association of Geology Teachers, 10th Annual Meeting. April 14-15, 1950. Illini Union Building, University of Illinois, Urbana, Illinois.

American Association of Petroleum Geologists, 34th Annual Meeting; Society of Economic Paleontologists and

Mineralogists, 23rd Annual Meeting; Society of Exploration Geophysicists, 19th Annual Meeting. April 23-28, 1950. Chicago.

American Geophysical Union, Annual Meeting. May 1-4, 1950. Washington, D. C.

International Speleological Congress. May 27-31, 1950. Monterrey, N. L., Mexico.

Rocky Mountain Federation of Mineralogical Societies, Annual Convention. June 7-9, 1950. El Paso, Texas.

California Federation of Mineralogical Societies, 11th Annual Convention. June 17-18, 1950. Trona, California.

American Federation of Mineralogical Societies, 3rd Annual National Convention; Midwest Federation of Geological Societies, 19th Annual Convention, June 28-30, 1950. Milwaukee Auditorium, Milwaukee, Wisconsin.

## Association of Geology Teachers 10th Annual Meeting

The tenth annual meeting of the Association of Geology Teachers will be held at the University of Illinois on Friday and Saturday, April 14-15. You are cordially invited to attend. The meeting is open to all persons interested in the teaching of geology.

The tentative program, as arranged by Dr. Paul R. Shaffer, follows:

Friday, April 14—Illini Union Bldg.

Morning—9:00—Registration and social session.

9:30—Session on "Field Courses and Methods". 3 papers, each to be followed by a discussion period.

Noon—Luncheon at the Illini Union.

Afternoon—Papers on "The Teaching of Mineralogy", each to be followed by a period of discussion.

Evening—Dinner at the Illini Union, to be followed by an address on some phase of Geology or the teaching of it.

Saturday, April 15—Morning—Business meeting and visits to the University of Illinois Geology Department and to the Illinois Geological Survey.

Please make reservations for luncheon and dinner Friday with Dr. Shaffer, Dept. of Geology, University of Illinois, Urbana, by April 11 or sooner if possible.

KATHERINE F. GREACEN, Secretary
Association of Geology Teachers

## Dr. Ingerson, American Editor of Geochemica ACTA

WASHINGTON, March 5 — Dr. F. Earl Ingerson has accepted an invitation to join the editorial board of Geochemica Acta, a new international journal devoted to the chemistry of the Earth and the Cosmos.

Dr. Ingerson is Chief of the Geochemistry and Petrology Branch of the Geological Survey and will serve as American editor of the new journal, to be published in London, England, by Butterworth-Springer, Ltd.

European editors will be Prof. F. A. Paneth, F.R.S., Durham; Dr. S. R. Nockolds, Cambridge; Dr. L. R. Wager, Durham, for England; Prof. F. E. Wickman, Stockholm, for the Scandinavian countries; Prof. C. W. Correns, Gottingen, for the German-speaking countries.

Papers on geochemistry and cosmochemistry will be published in one of the principal languages, English, French, or German, with English summaries.

"There is no journal in the United States devoted to geochemistry," comments Dr. Ingerson. "Geochemica Acta will fill a definite need. Papers on the subject are now widely scattered among a variety of journals and publications of scientific government bureaus."

# THE CONSTRICTION THEORY

RENE MALAISE

Swedish Museum of Natural History, Stockholm, Sweden

Geologists and other scientists have long puzzled over the cause of the vertical movements in the earth's crust. Gravity or convection currents have been proposed, but the forces apparently are not of a sufficient magnitude. Professor Nils Hjalmar Odhner of the Swedish Museum of Natural History, when confronted with the same problems, concluded that the only force available was the irresistible force of temperature. In 1934 he published the first account of his "Constriction Hypothesis", which is practically unknown outside of Sweden; and no one has considered its possibilities outside of the author. It was soon evident that most major geological problems could be solved with the help of this theory, and no serious objections have been presented. The influence of the theory spans over many different branches of science and many of the discoveries of recent years fit into the picture.

The earth's surface is undulated or wrinkled and these undulations are extremely variable in size. Geologists call the sharpest undulations geanticlines and geosynclines. These undulations are like low vaults. Generally speaking, those directed downwards, the geosynclines, are often marine depressions; and those directed upwards, the geanticlines, are highland sections of continents. The hard crust consists of different kinds of rocks, mainly granite; and since all rocks are influenced by changes in temperature, they will expand when heated and shrink when cooled. The undulations maintain their positions and are resistant to lateral pressure; consequently, each undulation will have its center raised or depressed into a higher arch when heated.

The interior of the earth is very hot, and its warmth is conducted to the crust and through it to the ocean waters and the surrounding atmosphere. The surface of the earth's crust is influenced accordingly by changes in the temperature of the surrounding atmosphere and, as a result, it will expand if the atmosphere is growing warmer or shrink if it cools. As the surface of the crust consists of undulating vaults, a rise in temperature will cause these undulations to be accentuated and vice versa.

As practical examples of such expansions, we may take the cables of the George Washington Bridge in New York City. In the summer they expand because of the higher temperature, with the result that the pavement sinks about one meter. In a marine depression the scale may be several thousand times larger; and the depth of the basin changes accordingly. On a continental block of 1,500 km., or about the size of the Labrador Peninsula, we may assume that the covering ice-sheet has disappeared after the end of the Ice Age, and the temperature of its layers of granite are raised 10° C. This would cause the center

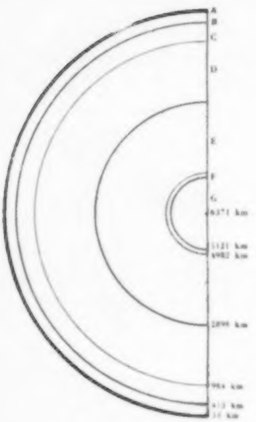

**Fig. 1 — The earth's interior according to K. E. Bullen (An Introduction to the Theory of Seismology, Cambridge, 1947).**

of this continental block to be raised about 958 meters, or 3,142 feet.

According to current views the uplift of glaciated tracts such as the Scandinavian and Canadian shields is due to recoil after the disappearance of the pressure of the covering ice-sheet. From the viewpoint of the constriction theory however, the uplift is the result of rising crustal temperatures.

From the contemporary studies of the velocity of seismic waves we know that the earth's mantle (Fig. 1, A-D) is solid, and has a marked rigidity down to a depth of 2,898 km.; but the velocity of the various seismic waves change somewhat at depths of 33, 413, and 984 km., possibly due to changed mineral composition induced by pressure. The initial strength of the material of the mantle (B-D) is not significantly less than that of the granite crustal layers (A). The outer region (E) of the core is essentially in a fluid state. The central part of the core (G) is significantly solid, i. e. possesses rigidity of the same order as the earth's mantle. The region F is possibly viscous. Even if the solid crustal layers were only 33 km., and all deeper layers were fluid, it is rather improbable that the weight of a 3 km. thick ice cover would be able to cause a sinking, considering the low specific weight of ice. With the thickness of the solid mantle amounting to 2,900 km., any movement in this mantle, such as convection currents, continental drift in the sense of Wegener, or the adjustment of a disturbed isostatic equilibrium, must be out of the question.

Figure 2: The upheaval of a mountain chain from the depth of a geosyncline.

**A.** In times of warm climate such as the Tertiary period, the temperature of the ocean bottom waters is too high to prevent the heat from the earth's interior from causing a rise in temperature of the earth's outer crust. The previously cooled, comparatively thin, continuous, and unfractured upper layers of the earth's crust, just below the outermost block-zone, thus become subject to a slow rise in its general temperature and will accordingly expand, chiefly in a lateral direction. The geosynclines and geanticlines of the crust are thereby forced to increase their curvature. The unfractured layers in an expanding geosyncline will, in addition to its own weight and that of the overlying fracture-zone, press on the subcrustal masses with tremendous force.

**B.** The pressure against the subcrustal masses increases as the curvature of the expanding vault is forced deeper down. Their pressure passes into heat and, under influence of heat and pressure, the subcrustal masses are compressed into minerals with a higher specific gravity. The subcrustal masses become softer and softer and finally become liquid locally.

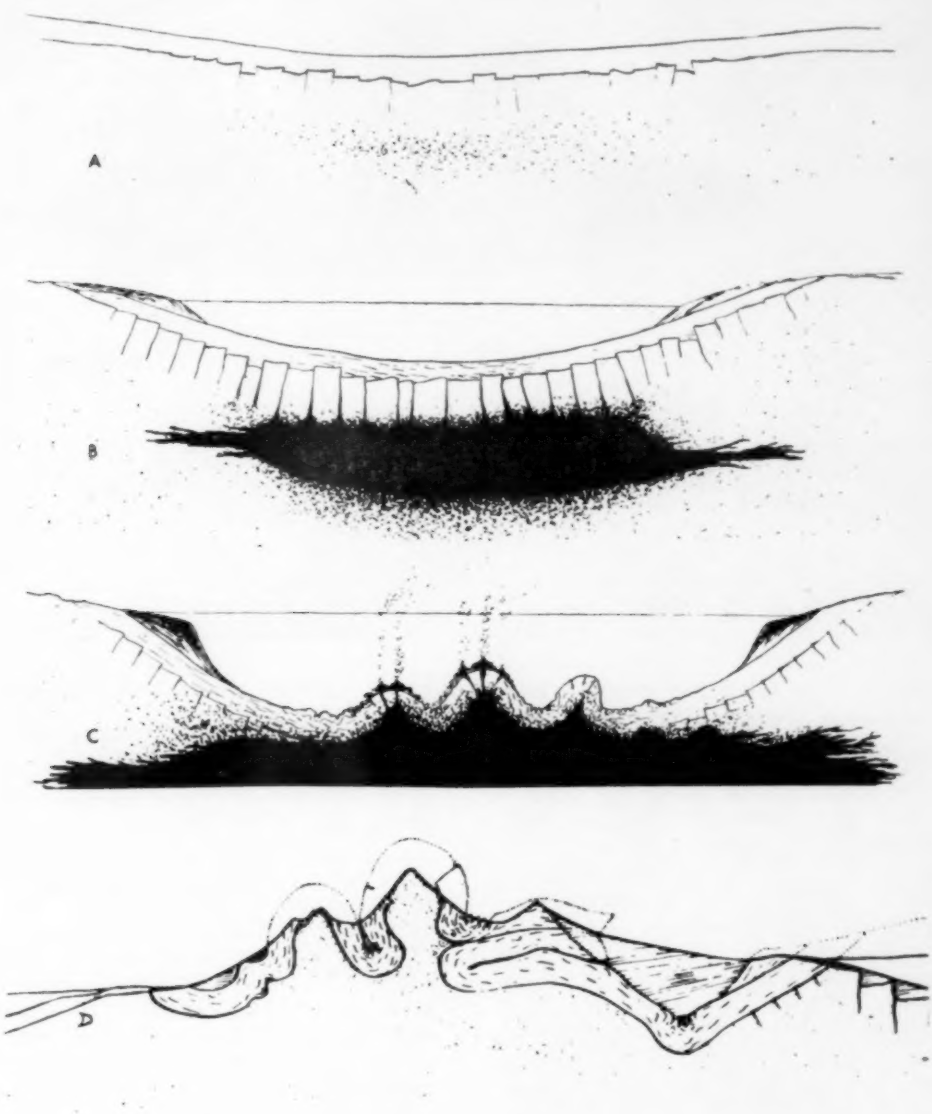


**Fig. 2 — The upheaval of a mountain chain from the depth of a geosyncline.**

**C.** As the synclinal vault is pressed still further down, closer to hotter layers, larger and larger quantities of the subcrustal masses beneath it turn liquid. Simultaneously, more and more of the vault itself becomes corroded and softened in its lower part, so that its initial strength and rigidity is diminished. In the end the vault cannot resist the tremendous counterpressure from beneath, but yields to it. From the bottom of the deep marine channel a new

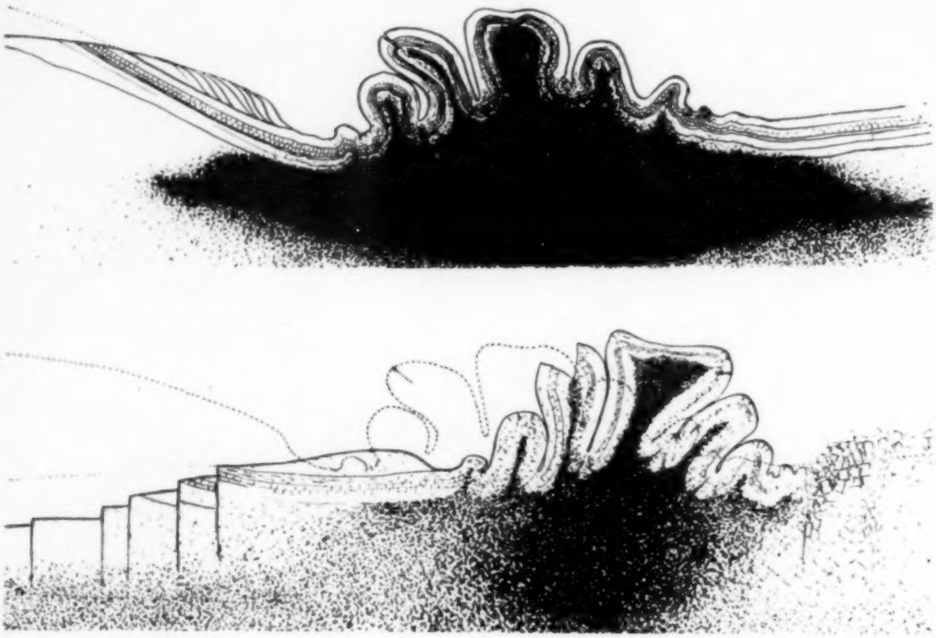

**Fig. 3 — The origin of arcuate mountain chains or island arcs and of submarine terraces on both sides of the Mid-Atlantic Ridge.**

mountain chain rises in mighty folds and swells. Together with the softened masses the sedimentary layers in the former synclinal vault are thereby strongly compressed and wrinkled from the sides when the bend of the vault passes on a smaller surface from a negative to a positive curvature.

D. The volcanic phenomena that may accompany the folding up of the new mountain chain probably cease rather soon. Simultaneously with the upheaval of the new chain the softer volcanic or sedimentary rocks, at the top of the rising mountain, are washed down as sand and gravel. When the pressure eases, the previously molten masses again solidify below the mountain. In the end these resolidified rocks appear on the surface transformed into granites or gneisses. Thus is explained the predominance of igneous rocks in many mountain chains.

Figure 3: The origin of arcuate mountain chains or island arcs and of submarine terraces on both sides of the Mid-Atlantic Ridge.

When the softened geosyncline yields to the counter-pressure from below and rises as a new mountain chain, it gives way simultaneously to the lateral pressure from the geanticlines on both sides. The observed intense lateral compression which most mountain chains have undergone is thus explained. If one of the lateral vaults is considerably stronger than the other it deforms the still soft mountain chain into an arc and tilts it at the same time towards the outer brim. The former geanticlines are eroded on the surface during their continental stage, and they consequently become geosyn-

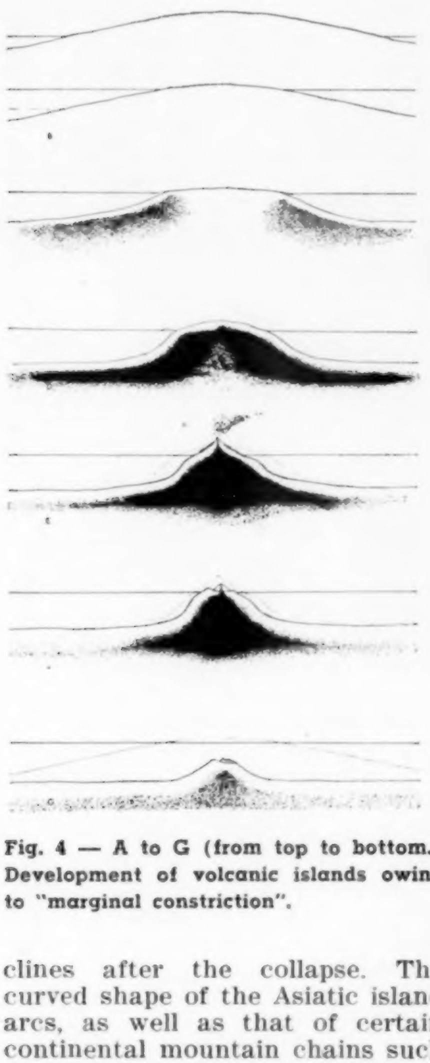

Fig. 4 — A to G (from top to bottom.) Development of volcanic islands owing to "marginal constriction".

clines after the collapse. The curved shape of the Asiatic island arcs, as well as that of certain continental mountain chains such as the Himalayas, is thus explained; likewise, the tilted and overthrust nature of the Japanese mountain chains towards the Pacific. The step-like submarine terraces on both sides of the Mid-Atlantic Ridge came into being when the former continental highlands collapsed and were turned into marine basins. The discovered strata under the terraces, but above the bedrocks, consists of sediments washed down from the former continental highlands. The absence of measurable sedimentary layers in the northwest Atlantic Basin itself indicates no great age for this basin; probably not older than Upper Miocene.

Figure 4: Development of volcanic islands owing to "marginal constriction".

**A.** A Tertiary highland between two marine basins. Owing to the warm climate of the Tertiary the continents were then over-elevated and the ocean water was concentrated into very deep basins. Extensive parts of the present sea-bottom were then dry land.

**B.** At the beginning of the great Ice Age the sea-level of the basins rose because the bottoms of the basins were cooled by cold water from melting glaciers, constricted, and were accordingly elevated. The subaereal origin of the now submarine canyons is thus explained. (The elevations of the bottoms are not indicated in the figures).

**C.** As a result of the cooling influence of the cold ocean water on the flooded parts of the former continents the crust below their margins was constricted and shrunk. The continental borders accordingly were bent down and sunk. Parts of the shores were then also warped down. The constricting crustal border exerted a strongly increasing pressure on the subcrustal masses. As a result these were compressed and became warmer and specifically heavier.

**D.** The cooling and constricting of the continental margins proceeds and the shores of the continent are flooded further and further inland. Owing to the increased pressure more and more of the subcrustal masses below the constricting margins turn liquid and are pressed towards the center of the land. The land has now become an island and its center is thus rising at the same time that its area is diminishing.

E. The now liquid subcrustal magmas are forced by the marginal pressure to penetrate the outer crust in the shape of lava, and create a volcano. When the volcanic eruption has continued for some time the local magma reservoir becomes drained and the volcano calms down until the reservoir is filled again as further subcrustal masses have turned liquid by the persistent marginal constriction. The surface of the island becomes more and more covered by volcanic materials. Many recent islands have reached this stage.

F. The down-warping of the shores and shelf of the island continues, and by now only the volcano proper remains above sea-level. The fauna and flora of the former continent have found a temporary refuge and develop further on the volcano. That is the reason why today many volcanic islands have a singular (endemic) fauna and flora surviving.

G. The last trace of the volcano has now disappeared below the surface of the ocean and only a submarine sea mount indicates the site and existence of the former continent.

Figure 5: Origin of deep and shallow earthquakes, marine troughs, tsunami waves, and volcanism along young (Tertiary) mountain chains on coasts of the Pacific type.

If a mountain range, running along a coast, becomes subject to marginal constriction, its submarine base and the broad ocean bottom outside the coast both constrict. These two constricting forces will then pull in opposite directions with tremendous forces. The limit between these diverging forces will coincide with the superficial crush-zone originating from the upheaval of the range, if this is still young. (Compare the lower right corner of Fig. 3). The diverging forces will, starting from these old cracks, tear apart the earth's crust, and a fissure or crack-zone filled with rock-pieces of all sizes will open up. As the cooling reaches further down, the fissure will proceed deeper and deeper, down to a depth of 600-700 km., at the same time it is slowly widening. Now and then the rocks in it will lose their hold and fall down until they again are wedged to a rest. The further penetrating cracks and the rock-falls cause the earthquakes, and the fore-deep marks the opening of the fissure. With such a deep and gradually yielding fissure running along the coast, the marginal constriction may press on the subcrustal masses with unrestrained force, make them liquid, and force them to escape through volcanoes. Along coasts with old ranges, as Norway or Brazil, the old superficial crack-zone has long since disappeared and has been replaced by a crust with greater initial strength. Here the continental slope merges gradually into the outer ocean bottom. The marginal constriction is therefore hampered by the pull and tension from the constricting ocean bottom resulting in a general subsidence without producing volcanoes, probably because the amount of subcrustal masses turned liquid is not sufficient. These masses may only make their way beneath the continent where they cause positive gravity anomalies. Volcanoes are thus nowadays confined to the vicinity of deep cracks or to islands, etc., where the marginal constriction may press from more than one side.

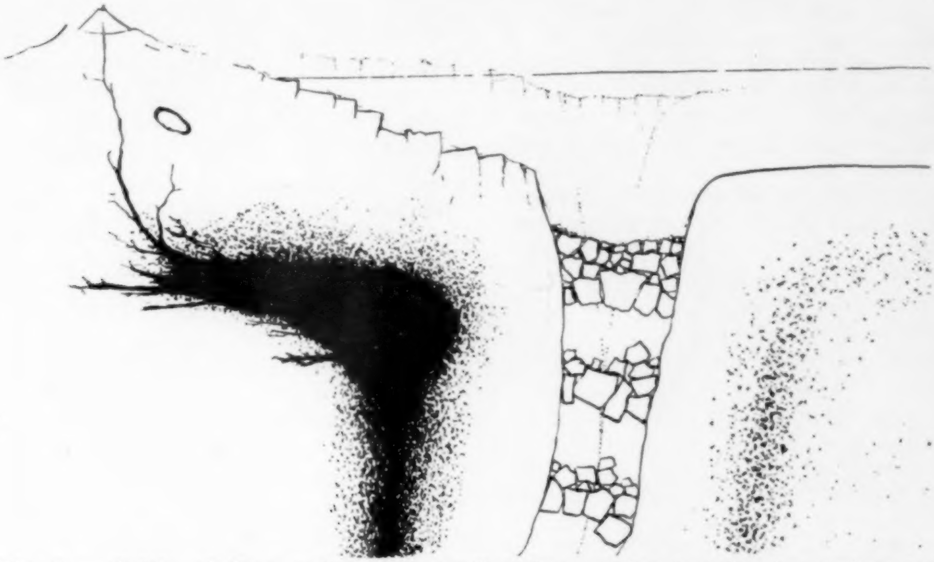

**Fig. 5 — Origin of deep and shallow earthquakes, marine troughs, tsunami waves, and volcanism along young (Tertiary) mountain chains on coasts of the Pacific type.**

The great seismic activity along the Mid-Atlantic Ridge makes the existence there of yet undiscovered crack-zones and troughs most probable.

The only published critique against the Constriction Theory was given by Dr. Kullenberg in 1945. It was founded on a mathematic calculation of the conduction rapidity of heat through granite and 100,000 years was claimed as necessary for temperature to proceed 6 km. in depth: but Scandinavia was raised after the Ice Age in a much shorter time. Every mathematical calculation is founded on certain assumptions, and if these are erroneous or doubtful, the entire construction crumbles to earth. In this case a number of vital facts have been left out of consideration, and it is most doubtful if we shall ever be able to determine mathematically the nature of processes under the condition of extreme pressure in the earth's interior. Scandinavia was subject to a Tertiary rise that was interrupted by the cooling ice sheet. The thermal isobath curves were acordingly concentrated, and subsequently the subcrustal minerals were compressed and made partially molten by the pressure. When this pressure ceased, resolidification and crystallization raised the temperature and more room was required. Other factors, such as water circulation in cracks, would tend to accelerate an upheaval. As long as we do not know all factors involved, it is safer to rely on observed effects than on such imposing formulae.

It is common error to believe that the expansion and contraction induced by changes in temperature primarily and exclusively affect the length of the earth's radius. Such variations occur, but they are so small that they may be neglected; because the thickness of the upper crustal layers, which are the only ones that undergo temperature alterations due to difference in cooling at the surface, amounts to only a few kms. The surface layers are, on the other hand, very broad; and the principal effect of a change in temperature will accordingly occur chiefly in the horizontal direction. The secondary vertical movements produced by the increase in curvature of the vaults is by far more important than the primary expansion. The active layer of the earth's crust is the homogeneous one just below the cracked surface block zone. Only in this layer can the constricting forces of cooling work with full effect.

The above pages and illustrations are based on a book in Swedish which will appear shortly under the name "Atlantis, en Verklighet", i. e., Atlantis, a Reality of Fact. The author's original purpose was to explain the geographical distribution of insects, which led to studies in geology and related sciences. All of the current theories on crustal movements were tested, but had to be rejected as either unsatisfactory or based on manifestly erroneous premises. The only theory that met the required demands for trustworthiness, simplicity, and common sense was the almost unknown Constriction Theory of Odhnar. On applying this theory to a multitude of unsolved geological problems such as orogenesis, secular movements, gravity anomalies, earthquakes, volcanism, and land bridges, all appeared understandable; and, in addition, climatical changes, marine currents, ice ages and related problems could be solved. With the possibility of proving geologically that the continent Atlantis remained above the surface of the ocean until about 2000 B. C., the old sagas of Plato became more trustworthy. Archeologists will probably have to revise their conception of the first discovery of America and of its colonization. Somebody in ancient Egypt must have known of the existence of America. Otherwise the following sentence quoted from Plato cannot emanate from the original text:

". . . . in those days the Atlantic was navigable from an island situated to the west of the straits which you call the Pillars of Hercules; the island was larger than Libya and Asia put together, and from it could be reached other islands, and from the islands you might pass through to the opposite continent, which surrounded the true ocean; for this sea which is within the columns of Hercules is only a harbor having a narrow entrance, but that other is a real sea and the surrounding land may be most truly called a continent. Now, the island was called Atlantis . . ."

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# Earth Science Abstracts

*[Selected articles on the earth sciences, appearing in current scientific publications, are abstracted here for the convenience of our readers.]*

## PHYSICAL GEOLOGY

THE VOLCANO PURACE. Victor Oppenheim. **Am. Jour. Sci.**, Vol. 248, No. 3 (March 1950), pp. 171-179. Purace is the only active vent of a group of Pliocene volcanoes in Columbia (some 30 km. S.E. of Popayan). This group is located on tectonic lines of crustal weakness of this part of the Andes. The explosive eruptions are intermittent and in recent times were not accompanied by lava flows. The volcano is about 2,000 meters above the crystalline basement of the Cordillera Central.

## ECONOMIC GEOLOGY

SALT PRODUCTION. Wendell G. Wilcox. **Scientific Monthly**, Vol. 70, No. 3 (March 1950), pp. 157-164. An interesting account of the mining of salt. In 1948 the total U. S. salt production was 16,303,293 short tons.

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SUBMARINE PHOSPHORITE DEPOSITS OFF CALIFORNIA AND MEXICO. K. O. Emery and R. S. Dietz. **Calif. Jour. Mines and Geology**, Vol. 46, No. 1 (Jan. 1950), pp. 7-15. Submarine phosphorite (calcium phosphate) nodules occur in large and extensive deposits on the sea floor from Monterey Bay southward to the Gulf of Mexico. A number of hypotheses have been proposed to account for their occurrence and distribution.

## MISCELLANEOUS

LONG LOST METEORIC STONES RECOVERED. Stuart H. Perry. **Am. Jour. Sci.**, Vol. 248, No. 3 (March 1950), pp. 214-219. Two stones from the Girgenti (Sicily) fall of 1853, weighing 8,750 and 2,151 grams, were acquired by the writer. 14,475 grams is now the total known weight of this typical white-veined chondrite. Both stones are covered with a fusion crust. A darkening to a brownish shade is attributed to oxidation of the nickel-iron, rather than to an incipient crusting or "scorching" during flight.

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ON THE POSITION OF PALAEONTOLOGY AND HISTORICAL GEOLOGY IN SWEDEN BEFORE 1800. Gerhard Regnell. **Arkiv for Mineralogi och Geologi**, Bd. 1, Nr. 1 (1949), pp. 1-64. In this comprehensive survey of the earlier development and position in Sweden (and Finland, which was part of the kingdom of Sweden at the period in question) of historical geology, paleontology, stratigraphy, and regional geology, the author discusses the contributions of Olaus Magnus, Swedenborg, Roberg, Bromell, Stobaeus, Linnè, Gyllenhaal, Modeer, Wallerius, Bergman, Betzius, Tilas, Hisinger, and others. An extensive biographical index, literary sources and bibliography are appended.

## RADIOACTIVITY

AGE OF URANINITE FROM A PEGMATITE NEAR SINGAR, GAYA DISTRICT, INDIA. Arthur Holmes. **Am. Mineral.**, Vol. 35, Nos. 1-2 (Jan.-Feb. 1950), pp. 19-28. An age of $955 \pm 40$ million years is determined for a specimen of uraninite from one of the pegmatites of the mica-belt of Bihar, India, by an isotopic analysis of the lead separated from the residue of the analysed powder.

DISTRIBUTION OF RADIOACTIVITY IN GRANITES AND POSSIBLE RELATION TO HELIUM MEASUREMENTS. Patrick M. Hurley, **Geol. Soc. America Bull.**, Vol. 61, No. 1 (Jan. 1950), pp. 1-8. Acidic igneous rocks give a much higher rate of emission of alpha particles than corresponds to the known total uranium and thorium content. A surficial distribution of the radioactive elements in the form of secondary mineral coatings on the surface of the granules is suggested. The surficial activity decreases in samples taken from considerable depth. Explanations are given for the low ratio of helium to radioactivity for the rock as a whole. The ratio for granites is only about one-fifth of what it should be for the true age of the rock.

**[The following abstracts are reprinted in part from Nuclear Science Abstracts, Vol. 4, No. 4 (Feb. 28, 1950), by permission of the U. S. Atomic Energy Commission.]**

REEF SURVEYING WITH RADIOACTIVITY. R. A. Stothart, **World Oil**, Vol. 130, No. 1 (Jan. 1950), pp. 61-63. Automatic recordings or radioactive emanations are used for delineating buried reef structures which are regarded as potential sources of oil. The shales which overlie oil zones yield radioactive emanations indicating the limitations of the oil productive area. The usefulness of the method is shown by the fact that out of seven radioactive anomalies mapped and later drilled, four opened new fields and one had oil shows.

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ON THE HELIUM CONTENT OF MINERALS CONTAINING BERYLLIUM, BORON, AND LITHIUM. V. G. Khlopin. **Doklady Akad. Nauk S.S.S.R.**, Vol. 66 (1949), pp. 893-894 (in Russian). The author decides that the high helium content in minerals containing beryllium, boron, or lithium, is not the result of a radioactive decay, and its only possible origin is a selective occlusion of the helium from its solution in the magma at the time of the crystallization of the minerals.

# Decade of Mineral Investigations By Mines Bureau

WASHINGTON, February 26 — More than 10,000 investigations of domestic deposits of 33 different minerals have been made by the Bureau of Mines during the past 10 years under a broad strategic minerals development program which charted and developed new reserves for war and peacetime use, Secretary of the Interior Oscar L. Chapman announced today in releasing a publication summarizing highlights of the program. About 1,300 projects in 48 states and Alaska, costing more than $29,000,000, were completed during 1939-1949, he stated.

Designed to make the United States more nearly independent of foreign mineral supplies, that program contributed substantially to war production in six of the mineral commodities investigated, and to a lesser degree in 12 others, Secretary Chapman said. A logical outgrowth of the threat of war in Europe in the late thirties, the program was authorized by the Strategic Materials Act of June 7, 1939. It is continuing on a smaller scale in peacetime.

Conducted by the Bureau of Mines in cooperation with the U. S. Geological Survey, this program made available for wartime use substantial supplies of aluminum, barite, celestite, mercury, tungsten and vanadium, Secretary

Chapman pointed out. On a lesser scale, new reserves of antimony, asbestos, chromite, copper, graphite, iron, fluorite, lead, talc, manganese, and zinc were made available, as well as pegmatite ores containing mica, beryl and other minerals.

The discovery of 21 million tons of comparatively high-grade bauxite in Arkansas was one of the outstanding results of the program, Bureau Director James Boyd said, and also 36 million tons of lower-grade bauxite, which probably could be used for manufacturing aluminum. Western iron ore deposits were extended to contribute to the establishment of the growing steel industry on the West Coast. New copper reserves were found, particularly the great San Manuel deposit in Arizona, now being developed by industry. Other projects yielded a major source of low-grade cobalt ore in Idaho, and proof of the existence of huge reserves of titanium in Florida sand deposits — subsequently developed by industry and now yielding important tonnages of titanium and other valuable minerals.

The investigations were concerned mainly with ore deposits too low in grade to be profitable in normal times, but suitable for use in case of an emergency, Director Boyd stated. This long-range objective of establishing "underground stock piles" was superseded temporarily early in the program by the immediate one of stepping up mineral production for war industries. Because of acute mineral shortages, production followed closely upon exploration in some cases, he added. At present, industry is actively developing or exploiting deposits of 14 of the commodities investigated.

Ore deposits investigated by the Bureau also included bismuth, calcite, corundum, industrial diamonds, kyanite and sillimanite, magnesium, molybdenum, nickel, potash, quartz crystals, sulfur, tin, and zircon, according to the publication. When the program got under way in 1939, seven metals on the strategic and critical list of the Army and Navy Munitions Board were investigated first, but the list expanded during the war and now includes about 50 metals and minerals.

In addition to drilling and other investigative work, the Bureau made numerous laboratory tests on minerals and developed new methods for using low-grade ores, the publication reveals. Development of the electrolytic process for making pure manganese from high-phosphorous manganese ores — unsuitable for steel — is a notable example of this.

The program was conducted by the former Mining and Metallurgical Divisions of the Bureau, with the assistance from the U. S. Geological Survey, State Geological Surveys and Mining Bureaus, as well as the contribution of industry and private individuals. Prepared by Lowell B. Moon, until recently chief of the Mining Division of the Bureau and now attending the Industrial College of the Armed Force in Washington, the publication includes an appendix listing the many publications on investigations completed during the 10-year period.

A free copy of Report of Investigations 4647, "Bureau of Mines Strategic Minerals Development Program, Summary of Progress, 1939-1949," may be obtained from the Bureau of Mines, Publications Section, 4800 Forbes St., Pittsburg 13, Pa.

# American Synthetic Quartz Crystals Developed From German Process

ITHACA, N. Y., Feb. 15 (Science Service) — The present successful process of making quartz crystals in the laboratory for use in radio and telephone applications was developed from a method in Germany found by postwar allied scientists, Dr. Albert C. Walker, of Bell Telephone Laboratories, stated here tonight.

Scientists tried to synthesize quartz over 100 years ago, he said. The purpose then was to learn more about the geological formation of the earth. In recent days the attempts to form quartz crystals in the laboratory have been to obtain a domestic supply for use in controlling radio transmission frequencies and in certain telephone applications.

Few crystals suitable for this purpose have ever been found in the United States. For the millions needed during the recent war, importation was necessary, although a few substitutes were developed.

Early synthesized quartz crystals were too small to be of practical use. From information secured in Germany in 1946, it appeared that Prof. E. Nacken of the University of Frankfort had grown quartz crystals in a few hours by a hydrothermal process, Dr. Walker stated, Unfortunately Prof. Nacken could make his process work for only short intervals of about 24 hours. To get large crystals, the process had to be repeated on a single crystal.

After nearly a year of research in the Bell Laboratories, the limitations of the German process were overcome. It is now possible to grow a quartz crystal weighing over one-quarter of a pound in a period of two weeks.

The value of the quartz crystal in radio and telephone applications is its piezoelectric property. Certain other crystals are piezoelectric but are either too costly or not satisfactory in such applications. Piezoelectric crystals, when subjected to mechanical pressure, give off electric charges; conversely, they can convert electrical energy into mechanical energy.

## Water Resources

### February 1950

Floods and high water prevailed generally from the Great Lakes region to the Gulf of Mexico. Record-breaking floods occurred in small areas in Ohio, Indiana, Missouri, and Louisiana. Monthly runoff of many streams was record-high for February.

Runoff was deficient from Wisconsin and Iowa to Montana. In the eastern part of that region runoff has been below normal since last summer. Throughout the West stream flow was generally well above normal except in parts of Canada and southwestern United States.

Stream flow was deficient in the Southeast with a new record-low February discharge in Alabama. Ground-water levels in New York and Connecticut continued the rise that started in December 1949. The outlook for normal spring runoff in the Northeast has improved greatly over a month ago.

— Water Resources Review

# THE DIVINING RODS OF SCIENCE

**[PART ONE OF A SERIES DEALING WITH GEOPHYSICAL EXPLORATION]**

CHARLES A. WILKINS

"Divining rods? Magic? Sensational pseudo-science!" Well, maybe not, but surely a person of a century or so ago would cry "Magic!", should he be shown the wondrous tools of the modern geologist in action.

Divining rods? Yes. For what else but divining rods are our Geiger counters, our mine detectors, our ultra-violet ray lamps, our seismographical oil locators? All these instruments and many more are the tools of the geologist. Divining rod! A rod, or anything else for that matter, when used for a specific purpose is a piece of equipment — in this instance, a piece of equipment that is used for the discovery of that which is obscure: hidden ore bodies, underground lakes of petroleum, the secrets of the earth's sub-strata.

The modern divining rod is no longer a forked twig. It may be a comparatively simple apparatus for measuring weak currents of electricity, or it may be a highly complex instrument with the elaborate system of detecting and recording indications. It may depend for its success upon a number of different principles, such as: magnetic attraction, electro-magnetic effects resulting from a combination of magnetism and natural or induced electricity, conductivity of the soil, gravitational pull, elasticity of rock formations, reflection or absorption of radio or acoustical waves, radioactivity, fluorescence, etc.

The surface of the earth has been pretty well explored locally by prospectors, and the visible outcroppings of the precious metals investigated. New methods — geophysical methods — are now necessary for locating deposits at greater depths where no surface indications exist, for mapping the subsurface extent of known deposits of such strategic ores as those of uranium, thorium, and tungsten, which would escape the naked eye.

Geophysical exploration may be defined as the prospecting for mineral deposits and geologic structure by surface measurement of physical quantities.

Geophysical exploration does not rely on magic or on any other supernatural procedure. It makes use of phenomena which can be interpreted fully through the fundamental laws of physics, measured and verified by anyone as long as suitable instruments are used. Thus, psychological reaction of the individual does not take part in the investigation. Therein lies the difference between the modern divining rod of geophysical exploration and the forked twig whose scientific merits have never been established. There may be persons who believe they can "sense" the presence of subsurface geologic anomalies; however, if they are so distinguished, they should have no need to surround their ability with a veil of mysterious devices.

Indeed this may be so, for the author can cite numerous authentic cases of persons endowed with extraordinary "vision", such as the recent case of 17-year old Pieter Van Jaarsveld of South Africa, who can "see" the hidden minerals far beneath the earth. He has located hundreds of mines and wells; his record of 95% success in finding water in that arid country would appear utterly impossible by the laws of chance. But discounting rare "vision" cases, experience has shown that the forked twig, contrary to geophysical instruments, will not give identical indications at the same place, or for different operators.

The primary object of geophysical exploration is the location of geologic structures; as a rule, information regarding the occurrence of specific minerals is obtained only in an indirect manner. Experience has demonstrated that most subsurface structures and mineral deposits can be located, provided that detectable differences in physical properties exist. The main properties exhibited by the more common rocks and formations are: density, magnetism, elasticity, and electrical conductivity. This entails four major geophysical methods: gravitational, magnetic, seismic, and electrical. These are employed in large-scale, broad-scope work. Also, you will probably find this aspect more interesting as well as of a more immediate application.

The subsidiary type of exploration relies on the specific properties; luminescence (i. e. fluorescence, etc.), radioactivity, and electrical. While the primary object specialized methods: ultraviolet reaction, radiation detection (alpha, beta, and gamma), and electrical. While the primary object is the exploration of subsurface structures and is broad in scope and extensive, the secondary object is relatively intensive, the difference lying in the difference between exploring a geologic structure for the possibilities of petroleum formation and the prospecting of a quarry for fluorescent and radioactive minerals, or even looking for buried treasure hoards.

Geophysics is indeed an unlimited field: a field in which the equipment of the geologist is made more efficient, more potent, with each advance of science — our modern magic; a field whose methods may be employed in discovering man's buried treasures as well as Nature's.

## USE OF GEOPHYSICAL INSTRUMENTS

From the heights we have peered down upon the physical principles and basic applications of a field that opens tremendous new vistas and offers potent new tools to the geologist.

It is proposed now to explain the different methods and instruments, based on scientific principles, which may be used for locating underground treasures consisting of ores, metals, oil, etc. There is no "perfect" diving rod. Many methods have been employed for locating hidden ores and metals, and many of them have been successful within reasonable limits. Some of the newer methods are still in the experimental stage, but their soundness of principle has already been demonstrated. Some which are not practical today can undoubtedly be made so as human knowledge increases, while others, based on superstition, will never succeed in anything but extracting money from the unwary.

That the methods based upon scientific principles have been employed with astounding success, does not mean that such devices are infallible, or even practical in all cases. There is an element of chance in many of these discoveries. Any instrument known today must be brought within a reasonable distance of a deposit of ore or treasure, in order to be affected by it; also, the operator of the instrument must know how to interpret the indications received, otherwise his equipment is useless. Also, it follows that the more the operator understands about his equipment and its functioning, and the more he understands of that upon which the use of his equipment is to be directed (geology, mineralogy, etc.), the more successful his results will be. Since reports of such discoveries lead many to believe that the perfect divining rod is at hand, and that easily acquired wealth is now within the reach of everyone equipped with a treasure finder, it is advisable for the prospector or treasure-seeker to become familiar with the various methods which have been employed, before investing money in something that may not prove practical for their particular needs.

It is well at this point to present a chart which illustrates the methods and basic principles of Geophysical Exploration in summary:

[see pp. 18-19]

## GRAVITATIONAL METHODS

Gravity has long been believed to vary with the density of the earth's crust, but only in recent years have instruments been designed that were sensitive enough to register these slight variations and thus reveal the character of the underlying strata. Variations in the gravitational field may be mapped by the pendulum, gravimeter, and torsion balance. The pendulum and gravimeter measure relative gravity, whereas with the torsion balance, the variations of gravity per unit horizontal distance, also known as "gradients" of gravity are determined. Since the gravitational effects of geologic bodies are proportional to the contrast in density between them and their surroundings, gravity methods are particularly suitable for the location of structure in stratified formations. As there is generally an increase in density with depth, the uplift of deeper formations will result in placing formations of greater density in the same horizontal level as lighter and younger formations.

## ACCUMULATION OF OIL

Oil accumulates in traps formed by wrinkling of the strata. In the Gulf Coastal Plain of Texas and Louisiana, the salt domes that have been investigated have nearly always been associated with oil, the oil being concentrated on the rim of these domes. There is no affinity between oil and salt, but the salt domes, pushing up from below, raise the strata and create convenient places for the oil to collect. A mere depression in the rock will not hold oil for the reason that water, being heavier than oil, will sink beneath it and force it out. A domestic pocket, however, holds the oil as a trap, and it cannot escape.

## THE TORSION BALANCE

The torsion balance consists essentially of a light aluminum bar suspended horizontally by a fine platinum wire on which is mounted a small mirror. A small gold or platinum weight is fastened horizontally on one end of the bar and an equal weight suspended vertically from the other end by

[Continued on page 20]

# SUMMARY OF THE FOUR MAJOR GEOPHYSICAL METHODS

| METHOD | FIELD | GEOLOGICAL APPLICATION | ACTION OF CONTROL |
|---|---|---|---|
| I. GRAVITATIONAL | | | |
| A. Torsion balance | Oil | Anticlinal structures; buried ridges; salt domes; faults; intrusions. | Spontaneous action, no depth control. |
| B. Pendulum<br>C. Gravimeter | | Salt domes; buried ridges; major structural trends | |
| II. MAGNETIC | Oil<br>Mining | Anticlinal structures; buried ridges; intrusions; faults; iron ore; pyrrhotite, and associated sulfide ores; gold placers. | |
| III. ELECTRICAL | | | |
| A. Self-potential | Mining | Sulfide ore bodies. | |
| B. Galvanic application of primary energy. | Mining,<br>Civil engineering | General structural conditions; bedrock depth on dam sites; ground water; oil structures; sulfide ore bodies; highway problems; electrical logging. | Reaction to energizing fields, control of depth of penetration |
| 1. Potential distribution of secondary of field measured.<br>a. Equipot., potential profile<br>b. Resistivity<br>Potential drop ratio | Oil | | |
| 2. Electromagnetic field means. | Mining | Sulfide ore bodies. | |
| C. Inductive application of primary energy. | Oil<br>Mining | Faults; anticlinal, etc. structure; sulfide ore bodies. | |
| VI. SEISMIC | | | |
| A. Refraction | Oil<br>Civil engineering | Salt domes; anticlinal, etc. structure; faults, foundation and highway problems. | |
| B. Reflection | Oil | Low-dip structures; buried ridges; faults. | |

SUMMARY OF MINOR GEOPHYSICAL METHODS

# SUMMARY OF MINOR GEOPHYSICAL METHODS

| METHOD | FIELD | GEOLOGICAL APPLICATION |
|---|---|---|
| V. UTILIZING ELASTIC PROPERTIES | | |
| A. Acoustic | Mining, civil engineering | Mine safety; pipe leak detection |
| | Military engineering | Sapper, submarine, airplane detection; sound ranging (SONAR) |
| | Navigation | Echo depth sounding; iceberg location |
| B. Dynamic vibration tests | Structural, civil engineering | Earthquake & vibration-damage tests of buildings, ground, and road beds. |
| C. Strain gauging | Mining, | Mine safety |
| | civil engineering | Tests of structures |
| VI. UTILIZING THERMAL EFFECTS | | |
| A. Geothermal | Oil exploration | Structural correlation of wells; cementation problems |
| B. Thermal detection | Military, navigation | Airplane location<br>Iceberg location |
| VII. GAS DETECTION | Oil, | Location of oil |
| | Mining | Mine safety |
| | Military | Poisonous gases |
| | Civil engineering | Gas leakers |
| VIII. RADIOACTIVITY MEASUREMENTS | Mining | Radioactive ores |
| | Oil | Well logging |
| IX. ULTRA-VIOLET FLUORESCENCE | Mining | Location of certain minerals |
| | Prospecting | Detection of oil |

a platinum thread about two or three feet long. In some types, two of these balances are used, placed at right angles to each other, so that two sets of readings may be taken.

The balance tends to rotate under the influence of an unequal force of gravity acting on the two platinum weights. This causes a torque in the supporting wire to which the mirror is attached. The position of a beam of light cast by the mirror is observed by means of a small telescope (or a photographic record may be made). It is evident that this is a very sensitive arrangement. Changes in the force of gravity of one part in a million may be detected.

The torsion balance is useful in locating iron ores, lead, zinc, copper and tin ores, salts, coal, and underground bodies of water, but its main use is in locating oil. As is usual in geophysical instruments, the torsion balance gives no direct indication of oil, etc., but from the observations made, the geologist can work out the location of structures favorable to oil accumulation. If placed directly over the center or an ore body, the instrument may give no indication of its presence, but if moved to the edge, the pull will be greater on one weight than on the other, and by moving it about and taking repeated readings the area of the body may be determined. The torsion balance, therefore, is essentially a gravity differential indicator. The complete outfit is somewhat cumbersome, as the balance must be well protected from undesired influences, such as moisture, air currents, temperature changes, etc., and elaborate provision is also made for recording the indications. Only a trained geologist can successfully use the torsion balance.

## THE GRAVITY PENDULUM

The gravity pendulum is another of the geophysical instruments that relies upon gravitational effects for its operation. The U. S. Coast and Geodetic Survey has conducted an extensive series of experiments to determine the practicability of the pendulum method of locating oil. This system, like that of the torsion balance, is based on the belief that there is a definite relation between the pull of gravity and the earth's crust. The greater the pull of gravity, the slower is the period taken for a pendulum of given mass to swing through a complete cycle; from this it is evident that the denser the sub-structure, the greater the time will be for one cycle of pendulum swing. The success of this system depends upon the very accurate measurement of the swing of the pendulum in regard to the time consumed, and its comparison with tests made at other points.

The pendulum is delicately suspended on a knife edge, and the frictional losses are so low that, on being started by a touch of the hand, it will swing for twelve hours. The pendulum is suspended in an airtight case, and its oscillatory period for a known pull of gravity is accurately measured. Once calibrated, it is ready for use. A small mirror is mounted on the pendulum, so as to throw a beam of light which may be observed through a small telescope. Tests carried out in a new territory will show differences in oscillatory period; when these differences are compared to the original calibration, the pull of gravity in the new territory may be derived. The extreme accuracy of work done with this instrument places it high in standing among the gravitational measuring instruments.

## THE RADIOMETER

Nearly everyone has noticed the little glass globe of the jeweler's window, containing the four little disc or squares which revolve in so mysterious a manner. This apparatus is known as a radiometer, or sometimes, a "sun motor", and was designed for measuring the mechanical effects on one side. The wheel is suspended in a partial vacuum on delicate bearings. When struck by a ray of light, the paddles revolve with a speed depending upon the heat-producing effects of the light ray, and the pull of gravity.

A radiometer is mounted in a light-proof case, and so arranged that a single ray of light supplied by a small bulb will strike the paddles and cause them to revolve. Through a small periscope the operator can watch the revolving wheel and check the speed of revolution. The complete outfit is mounted on a tripod, and is called a "gravitometer".

Variations in the force of gravity cause variations in the speed of the paddle wheel by increasing or decreasing the bearing friction. Like the pendulum, its speed must be calibrated with a known gravitational pull; also, we must know accurately the amount of heat produced from the light beam at calibration, and means must be incorporated to keep this radiation constant, or provide means for measuring it at all times so that the proper correction factor may be entered, due to wearing out of the battery bulb. Its use, like the pendulum, is to measure the pull of gravity by measuring the speed of rotation of the paddle wheel, and comparing it with the calibration speed.

## GRAVIMETERS

Dynamic methods (pendulum, gravitometer) of measuring gravity have been superseded recently by "static" or "gravimeter" methods, in which gravity is compared with an elastic force. Mechanically simplest are the Threfall and Pollock instruments suspended from a horizontal torsion wire, the Hartley gravimeter which contains a horizontal hinged beam suspended from two helical springs, the Lindblad-Malmquist and the Askania gravimeters in which the masses are suspended directly from a spring or springs, with arrangements for electrical or optical means for magnifying the displacement. The pull of gravity may be measured directly with the gravimeter, and its use in field geophysical exploration is the same as that of the other gravitational instruments after the pull of gravity has been measured.

Gravitational methods, accurate though they may be, are nearly equivalent to bringing the laboratory with its attendant laboratory technique into the field, and, therefore, are suitable more nearly to extremely thorough, large-scale exploration undertaken by the trained geophysicist.

**(to be continued)**

[Reprinted in part from the Georgia Mineral Society News Letter.]

## Cover Photo

This view of the Lower South Falls of Silver Creek Falls, near Salem, Oregon, was taken by Dr. W. D. Keller. Some people are barely visible walking along the path which runs midway in the picture behind the falls, a 100-foot drop over basalt layers.

# New Books

**All books listed here are deposited in the Library of The Earth Science Institute and may be borrowed by the members. Books marked with an asterisk may be purchased through The Earth Science Publishing Co., Revere, Mass.**

### *THIS EARTH OF OURS — PAST AND PRESENT.

C. Wroe Wolfe. 1950. 384 pp., 239 figs.; $5.00. (Earth Science Publishing Co., Revere, Mass.). In this new textbook for the beginning student, the author emphasizes the philosophical aspects of geology and its unsolved problems, such as the causes of metamorphism, glaciation, and mountain building; the origin of the earth, and of life; and the nature of evolution. The author presents his new blister theory as a working hypothesis to explain most of the major problems of diastrophism. Historical geology is presented first through the regional geology of North America, then the history of the continent, and finally by an extensive treatment of the history and evolution of life. The appendix contains mineral and rock tables, and introductions to topographic maps and fossils. The book is well illustrated, especially in the chapters on running water and the history of life.

### *REBELLIOUS RIVER

J. P. Kemper. 1949. 279 pp., 7 figs.; $6.00 (Bruce Humphries, Boston). An interesting account and analysis of the problem of flood control, with particular reference to the Mississippi River and its tributaries, especially the Red River and the Atchafalaya River. Although this book presents some interesting material on river hydraulics, it is mainly concerned with flood control legislation. It is filled with a wealth of statistics and historical accounts of past floods. The author believes that the Atchafalaya River will be adopted by the Mississippi as its main channel. Present problems are presented and future courses of action are suggested.

### REPORT OF THE COMMITTEE ON THE MEASUREMENT OF GEOLOGIC TIME—1948-1949.

John Putnam Marble, Chairman. 1949. 139 pp.; $1.00. (National Research Council, Division of Geology & Geography, Washington 25, D. C.). In addition to the summary report of the Committee and the annotated bibliography, the following articles are included in the report: Japanese Analyses of Radioactive Minerals, 1936-1946; Late Pleistocene Dates Derived from Radiocarbon Assay; Present Status of Absolute Age Measurement in Brasil; Report to Committee on Measurement of Geologic Time; Some Problems of Age Measurements on Eastern North America Magnetites.

### NIAGARAN REEFS IN ILLINOIS AND THEIR RELATION TO OIL ACCUMULATION.

H. A. Lowenstam. 1949. 36 pp., 1 pl., 9 figs.; free. (Report of Investigations No. 145, Illinois State Geological Survey, Urbana, Ill.). The first oil production in Illinois to be obtained from reef atolls was the Marine pool in Madison County in 1943. The subsurface Silurian strata have been systematically examined to determine the occurrence and spacing of Niagaran reefs, and their distribution is delineated as a guide for future oil exploration.

### GEOLOGY AND ORE DEPOSITS OF THE LA PLATA DISTRICT, COLO.

E. B. Eckel; J. S. Williams, F. W. Galbraith, et al. 1949. (1950). 179 pp., 29 pls., 50 fig; $2.50. (U.S.G.S. Prof. Paper 219; Supt. of Documents, Govt. Printing Office, Washington 25, D. C.). The La Plata mountains in southwestern Colorado are an excellent example of a laccolithic mountain group, having been carved from a domal uplift of sedimentary rocks that have been intruded by late Cretaceous or Tertiary igneous rocks. This district is best known for its deposits of gold- and silver-bearing telluride ores.

GEOLOGY AND MANGANESE DEPOSITS OF THE LUCIFER DISTRICT, BAJA CALIFORNIA, MEXICO.
I. F. Wilson and Mario Veytia. 1949 (1950). 57 pp., 18 pls, 1 fig.; $1.75. (U.S.G.S. Bulletin 960-F; Supt. of Documents, Govt. Printing Office, Washington 25, D. C.). The Lucifer manganese mine has produced more manganese than any other mine in Mexico, although its development did not begin until late in 1941. The total size of the ore body is about 300,000 tons, of which about half has already been mined.

# Devil's Tower National Monument Mapped

WASHINGTON, March 17 — Special topographic maps of Devil's Tower National Monument in Wyoming have been edited and published by the U. S. Geological Survey. This area in Crook County was the first national monument in a system which now covers a whole series of floral, faunal or geological wonderlands throughout the country. It was established by proclamation of President Theodore Roosevelt in 1906 under the authority of the "Antiquities Act."

Survey experts laboriously mapped the Monument area in 1933 by transit and plane-table methods. During the last field season it was revised to turn out not only the usual contoured precision map but another which shows the Tower and the surrounding country in shaded relief. This is the very latest development in visual terrain representation. Even those who seldom read maps can tell at a glance exactly what sort of ground they are dealing with.

Devil's Tower is west of the South Dakota Black Hills in a part of Wyoming where erosion has been at work on the softer rocks, sod and ground cover for at least a million years or so. Here the surface of the ground has been lowered by hundreds of feet and torrential downpours from cloudbursts and intermittent streams are still at work.

As to how this great mass originated, geologists are not in agreement. However it seems certain that at one time molten material from below lifted the overlying layers of sedimentary rock and formed several such domes as Devil's Tower. It has been suggested that perhaps the shaft as it now stands is hardened lava that was once in the neck of an old volcano, the enclosing walls of which were removed by erosion.

Nearby are several partially uncovered masses of igneous rock. The fluted columnar structure is ascribed to contraction and cracking as the molten mass rapidly cooled. Whatever the explanation, hundreds of feet of surrounding rock have obviously been worn away by the action of water and carried toward the sea.

The new maps are available at 20 cents each and may be obtained by addressing The Director, U. S. Geological Survey, Washington 25, D. C.

For an interesting account of Devil's Tower, see "The Touring Public Discovers Mato Tipi" by H. P. Zuidema, in the August 1948 **Earth Science Digest.**

# Carnotite and Radioactive Shale In Missouri

G. A. MUILENBERG, Missouri Geological Survey
and
W. D. KELLER, University of Missouri

Carnotite and perhaps another radioactive mineral in shale have been found in Ste. Genevieve County in southeastern Missouri. This is the first reported occurrence of carnotite in Missouri. It no doubt will excite interest in radioactive mineral possibilities in geological occurrences other than those of pitchblende-type veins and the Colorado-Utah plateau carnotite deposits.

In July, 1949, Mr. Charles Bussen found in his limestone quarry about five and one-half miles north of Ste. Genevieve, Missouri, a small amount of a yellow mineral (carnotite) along a blasted joint in the Spergen (Mississippian Age) limestone. The mineral was determined to be carnotite, a vanadium uranium vanadate by the Missouri Geological Survey (Muilenberg). Further exploratory work revealed additional carnotite in a "hot" radioactive black shale layer in the limestone. Confirmatory determination of carnotite from the yellow coating on shale surfaces were made by X-ray (Keller) and spectrographic methods (Dr. E. E. Pickett) at the University of Missouri laboratories.

Although the non-yellow portions of the shale may likewise be radioactive the mineral source of that radiation is not known at present. A tentative hypothesis is that the illite mineral of the shale may contain the vanadium and uranium. Preliminary work by the Missouri Geological Survey on fractionation of the shale was not effective in concentrating the radioactive material in any special fraction. The X-ray powder diffraction pattern of the non-carnotite portion of the shale showed the clay mineral of the shale to be illite, and the spectrographic results showed it to contain vanadium and uranium. Hendricks suggested the vanadium of some western shale to be a part of the illite mineral. Possibly illite may contain the radioactive elements in the Missouri shale, but this has not be proven. An alternate possibility is that the carbon of the black shale holds the uranium compound by adsorption.

Further field and laboratory work on the occurrence, mineralogy, and origin of the radioactive minerals is being carried on by the Missouri Geological Survey and members of the University of Missouri Geology Department.

A single occurrence of metatorbernite, a hydrated copper uranyl phosphate, was reported from a flint fire clay pit near Gerald, Missouri, 1941, by O. R. Grawe in Bulletin 28 of the Missouri Geological Survey.

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[An article by Drs. Muilenberg and Keller on this interesting occurrence of carnotite and radioactive shale will soon appear in the **American Mineralogist.**]

# New Coal Reserves Found In Maryland

WASHINGTON, Feb. 14 — Discovery of more than 600,000,000 tons of semi-smokeless coal in the lower beds of the Georges Creek field in Allegany and Garrett Counties, Md., was announced by Secretary of the Interior Oscar L. Chapman.

The new reserves are found in 10 coal beds buried below the two that have provided most of the field's coal production. Those two beds have been mined for many years and are being worked out. As a result, production, which was about 2,250,000 tons a year before 1931, is now approximately 1,800,000 tons.

Little was known about the coals in the lower beds until the Bureau of Mines and the U. S. Geological Survey, with the cooperation of the Maryland Department of Geology, Mines, and Water Resources, explored them between 1944 and 1946. Diamond drilling, eximination of operating mines and accessible abandoned ones, and a geologic study of the area yielded the estimate of reserves. Only coal beds 18 inches or more thick were included.

The coals rank as low-volatile bituminous, and carbonization tests showed that they yielded strong coke. It was found that the ash and sulfur contents, although rather high, can be reduced by washing, and that some of the coals may be suitable for use in blends to produce metallurgical coke. Another suggested use is as fuel in nearby metropolitan areas, such as Washington and Baltimore.

A technical paper describing the studies observes that while it may not be economically feasible to mine 18-inch coal in the Georges Creek field at present, the estimate of reserves includes over 150 million tons in beds over 36 inches thick, and more than twice that quantity in beds from 24 to 36 inches thick. It also observes that while recovery of coal from mines now operating in the field averages 50 to 60 percent, modern mechanized mining methods should increase recovery to 75 or 80 percent.

Copies of Bureau of Mines Technical Paper 725, "Investigation of Lower Coal Beds in Georges Creek and North Part of Upper Potomac Basins, Allegany and Garrett counties, Md., with Maps." can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for $4.75 a copy.

## Geological Survey Remaps Niagara Falls

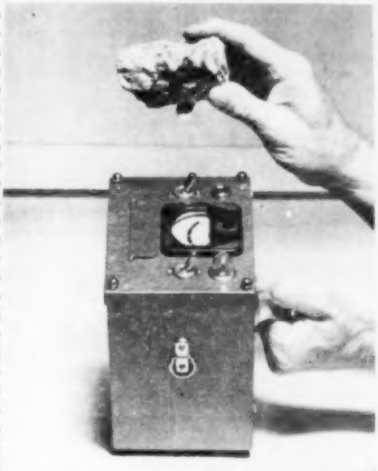
WASHINGTON, Feb. 24 — Completion of the new large-scale mapping of Niagara Falls and vicinity was announced today by Secretary of the Interior Oscar L. Chapman, following publication of this key sheet in a series that will eventually cover the entire State of New York.

The work is on a cooperative basis with the New York State Department of Public Works augmenting Federal funds. The scale of the new map of the Falls is 1:24,000 (1 in. = 2000 feet) with relative elevations of the land above sea level shown by contour lines at 10-foot intervals.

Primary survey control was furnished by the U. S. Coast and Geodetic Survey, U. S. Lake Survey, and the International Boundary Commission. Culture and drainage were in part compiled by the Corps of Engineers, Department of the Army, from aerial photographs taken in 1942. Present-day, national map-accuracy standards have been carefully followed.

The map includes only the Niagara River and land features of the United States to the east. The Canadian portion is blank except for inclusion of Canada's highway bordering the river. Niagara River features are shown from a point 4.3 miles above Beaver Island State Park, north to The Whirlpool, well below the Falls.

Shown on either side of Goat Island are the American Falls and Horseshoe Falls with the portion well known to travelers as Bridal Veil Falls precisely indicated. Rainbow Bridge and the Whirlpool Rapids Bridge are represented, also the railroad marshaling yards of the New York Central and Erie Railroads. Indicated by a red tint are the densely populated sections of Niagara Falls, N. Y., cointaining landmark buildings.



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